J. Agr. Sci. Tech. (2017) Vol. 19: 279-291

Regional Simulation of Bootstrap Efficiency of Broiler Production in Peninsular Malaysia

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ABSTRACT

Bootstrapping the DEA is one of the current methods of measuring robust efficiency by constructing a confidence interval and measuring the noise (bias) in production. In this study, two estimators: the conventional Data Envelopment Analysis (DEA) and bootstrap simulation with 2,000 bootstrap iterations were applied on a cross sectional data of 296 broiler farms in Peninsular Malaysia. The objective of the study was to measure the robust technical efficiency, production bias and factors motivating technical efficiency in the Northern, Southern, and East-central regions of Peninsular Malaysia. As a regional approach, the study found the existence of both inefficiency and noise in broiler farms across regions of Peninsular Malaysia. Findings show disease infestation and unfavorable temperature as components of noise or exogenous factors or factors beyond farmers' control in broiler production. The study identified age (+), education (+), experience (+), production system (-), number of poultry farms owned (-), business status (+) and land tenure status (-) as statistically significant in ameliorating efficiency in broiler production. Result also show that strong statistically significant differences exist in the magnitude of technical efficiency scores between the two estimators across the regions. The study advocate for increase in scale of production as majority of the farmers produce at increasing returns to scale.

Keywords: Bias-corrected, FEAR, Frontier, Iteration, Robust.

INTRODUCTION

As a dominant sub-sector of the Malaysian livestock industry, the poultry (broiler) industry exerts immense contribution to the economy and the largest source of meat to the populace. Production index indicates the production of 636,997,602 broiler birds in Malaysia in 2012 (DVS, 2013). This translates to 12.25 million and 1.75 million birds on weekly and daily basis, respectively, for the year. The volume of broiler exports accounts for 42.78 million live birds and 13,816 MT of raw marinated chicken meat to the rest of the world and imports of 41.27 MT from China, Thailand and Holland. With a per capita consumption of 38 kg head^{-1} year^{-1} (DVS, 2013), its high demand is relatively attributed to its low-cost and it is religiously acceptable among the faiths in the nation. Ironically, in spite of the overwhelming National Self Sufficiency Level (NSSL) of 128% (DVS, 2013), importation of chicken meat (cuts and products) from the rest of the world persist. Between 2011 and 2012 alone, importation of chicken meat rose by 4.6%. Although importation exist to satisfy local demand for the various forms of value addition of the broiler meat as obtainable in other global communities and foster persistent trade relations, the cost of the importation is quite alarming and if the influx of broiler meat continues unabated, worse than anything, it will hamper the survival and sustainability of the broiler industry. Broiler feeds constitute one of the major resource related problem of the industry, regardless, the industry has thrived to record a National Self Sufficiency Level

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(NSSL) of 128%. Certainly, the industry could have witnessed prosperity more in the absence of production issues confronting her. In view of the prospects inherent in Malaysia's broiler industry and the zeal for economic diversification, addressing current issues in the industry is not only essential but also expedient.

Cost of feeds is one of the most serious constraints in Malaysia's broiler production. Ariffin *et al.* (2014) asserted that the poultry sector in Malaysia is constraint with high cost of broiler that constitutes about 70% of production cost. Meeting the amino acid and protein requirements for the birds in feed formulation is the most expensive component of the feeds (Corzo *et al*., 2005; and Darsi *et al*., 2012). However, the application of phytase nutrient equivalency values in formulating feeds aids reduce feed cost and ensures nutrients availability (Zaghari, 2009).

In line with the foregoing, the purpose of this study was to estimate the level of technical efficiency/inefficiency and determine factors influencing efficiency in the Northern, Southern and East/Central regions of Peninsular Malaysia. Furthermore, the study disaggregated the frontier deviations in broiler production into actual inefficiency and noise (exogenous factors) via the bootstrap simulation.

MATERIALS AND METHODS

Study Area

Peninsular Malaysia is otherwise called West Malaysia and known formerly as Malaya; it constitutes the largest segment of Malaysia. It lies on Malay Peninsular and shares border with Singapore to the South, Thailand to the North, Sumatra (Indonesia) to the West and Borneo Island and South China Sea to the East. With a population of 23.5 million in 2012, the Peninsular accounts for 80% of Malaysia's population and economy. There are four regions (Northern, Southern, East-Coast, and Central) in Peninsular Malaysia. But, due to paucity of respondents in some regions; particularly East-Coast and Central; the two regions were merged as East/Central region for the sake of analysis. Hence, for the purpose of this study, Northern, Southern and East/Central regions are used.

Source of Data

A primary source of data was used for this study and a structured questionnaire was used for data collection. This research composed of broiler operations for only one cycle or period of production in 2013. The study is limited to Peninsular Malaysia only (excluding Sabah and Sarawak (East Malaysia)) due to the difficulty in obtaining data and its associated high cost of logistics in the East Malaysia. More so, Peninsular Malaysia accounts for 80% of Malaysia's population and economy. Similarly, the majority of broiler production activities also take place in the Peninsular.

Sampling Method

To ensure representative and heterogeneous data, a stratified random sampling technique was used for data collection. The poultry farms were stratified into two stratum: Scale of production (small scale, medium scale, and large scale) and system of production (open and closed systems). Using the above stratification, a simple random sampling was used to draw a non-proportionate samples/ farms from the major broiler producing states (Melaka, Negeri Sembilan, Perak, Johor, Penang, Pahang, Kelantan, Selangor and Kedah) of the peninsular. DVS (2012) reported a total of 2,000 registered poultry farms in the peninsular. Applying Yamane (1967) equation for sample size estimation led to 399 sample size selected for the study.

After data collection, about 103 of the questionnaires were discarded due to incomplete data or inaccurate data. Thus, data from 296 farms were used for the analyses in this study.

Table 1 shows the descriptive statistics of production variables in broiler production. The table shows high values of standard deviation which indicates that there is wide variation in the levels of broiler production in Peninsular Malaysia. This wide variation in production is not surprising since the sample of the study composed of farms in small, medium and large scale broiler production. Feeds (X_2) and Day Old Chicks (DOC) (X_1) are the most varying inputs in broiler production as observed. Their means in decreasing order of magnitude are Southern, Northern and East/Central regions. This justifies the fact that in Peninsular Malaysia, DOC production farms and broiler feed mills are highest in the Southern, next the Northern, and then East/Central (combine) regions. The statistics also reveals that most of the large scale broiler farms are concentrated in the Southern region. DVS (2013) reported that out of the 79 parent stock farms for DOC in 2012, 47 (59.49%), 23 (29.11%), 6 (7.59%) and 3 (3.80%) were located in the Southern, Northern, East-Coast and Central regions, respectively.

Analytical Tools

A combination of conventional DEA and DEA-bootstrap procedures are used for analysis in this study. On the whole, 2 soft wares were used; FEAR in R-Software, for estimating Technical Efficiency (TE) under both conventional DEA and bootstrap assumption and STATA for analyzing factors influencing bootstrap *TE*.

Table 1. Descriptive statistics of variables used in broiler production in Peninsular Malaysia.

Variables	Min	Max	Mean	*SD*
Northern Peninsular				
X1-Day old chicks (Number of chicks/Set)	7500.00	250000	49263	45943.26
X2-Feeds (Kg set^{-1})	4750.00	692000	127882	121805
X3-Labour (Man-hours/Set)	240.00	4760	958.4	673.26
X4-Medication [Vaccines and vitamins(RM/Set)]	140.00	52000	11425	12280.16
X5-Utilities [Maintenance+water+saw dust+electricity+gas+oil (RM/Set)]	214.00	43000	8628	8997.03
Y-Output of chicken (Kg set^{-1})	14625.00	540114	102982	97241.41
Southern Peninsular				
X1-Day old chicks (Number of chicks/Set)	7500.00	380000	72131	74183
X2-Feeds(Kg set^{-1})	10000.00	1749500	188556	220447
X3-Labour (Man-hours/Set)	232.00	6624	1508	1231
X4-Medication [Vaccines and vitamins(RM/Set)]	225.00	121600	14754	18209
X5-Utilities [Maintenance+water+saw dust+electricity+gas+oil (RM/Set)]	700.60	374080	17001.2	34006.8
Y-Output of chicken (Kg set^{-1})	15384.00	840065	150972	156892.47
East/Central Peninsular				
X1-Day old chicks (Number of chicks/Set)	1800.00	91000	21223	20456
X2-Feeds (Kg set^{-1})	5000.00	410000	71570	83176
X3-Labour (Man-hours/Set)	240.00	3264	940.8	666
X4-Medication [Vaccines and vitamins (RM/Set)]	100.00	28000	3036	5045
X5-Utilities [Maintenance+water+saw dust+electricity+gas+oil (RM/Set)]	196.00	22600	4628	5018
Y-Output of chicken (Kg set^{-1})	3494.00	196560	44977	44373.83

Survey data (2013).

Sample Size Determination

The study used Yamane (1967) sample size equation to determine the sample size or number of farms selected for this study. The equation is as below:

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where; n= Sample size; N= Population size, and e= Sampling error.

Data Envelopment Analysis (DEA)

The pioneer proponents of DEA, Charnes *et al.* (1978) introduced the CCR model for constant returns to scale assumption. Another significant development in DEA is the introduction of the BCC model by Banker *et al.* (1984) for measuring efficiency under variable returns to scale. Given $X_{ij} and\ Y_{rj}$ as the i^{th} input, I= 1,…, m. The r^{th} output, r= 1,…, s, respectively, of the j^{th} firm, j= 1,…, n. Efficiency under constant returns to scale assumption (CCR model) is estimated as:

$$E_K^{CCR} = Max \sum_{r=1}^{s} U_r Y_{rk} \quad (2)$$

subject to

$$\sum_{i=1}^{m} V_i X_{ik} = 1$$
$$\sum_{r=1}^{s} U_r Y_{rj} - \sum_{i=1}^{m} V_i X_{ij} \le 0, j = 1, \dots, n, \quad (3)$$
$$U_r, V_i \ge \varepsilon, r = 1, \dots, s, i = 1, \dots, m$$

Where, E_K^{CCR} as *CCR* efficiency is termed as overall efficiency, $U_r\ and\ V_i$ are known as virtual multipliers and ε is called a small non-Archimedean number imposed to avoid ignoring any factor (Charnes *et al.*, 1979).

Similarly, the BCC model for estimating efficiency under variable returns to scale assumption is as below:

$$E_k^{BCC} = Max \sum_{r=1}^{s} U_r Y_{rk} \quad (4)$$

$s.t.$

$$V_0 + \sum_{i=1}^{m} V_i X_{ik} = 1,$$
$$\sum_{r=1}^{s} U_r Y_{rk} - \left(V_0 + \sum_{i=1}^{m} V_i X_{ij}\right) \le 0, j = 1, \dots, n, \quad (5)$$
$$U_r, V_i \ge \varepsilon, r = 1, \dots, s, i = 1, \dots, m,$$
$$V_0\ is\ unrestricted\ in\ sign$$

Banker *et al.* (1984) termed the *BCC* efficiency (E_k^{BCC}) as the technical efficiency and further stated that the ratio of the *CCR* efficiency to the *BCC* efficiency is the scale efficiency (E_k^{Scale}).

$$E_k^{Scale} = E_k^{CCR} / E_k^{BCC} \quad (6)$$

Bootstrapping the DEA

This study also used the homogenous smoothed bootstrapping technique proposed by Simar and Wilson (1998) to estimate the bootstrap *TE*, confidence interval and the bias or noise component. Bootstrapping as a simulation technique that employs Monte Carlo test (approximation) to simulate the Data Generating Process (DGP) to generate robust (valid) estimator of the unknown DGP (Gocht and Balcombe, 2006). This technique is an improvement on a limitation of lack of noise associated with the conventional DEA estimator. Gotch and Balcombe (2006), given a Data Generating Process (DGP) set up, P yields random sample$X = \{x_k, y_k \mid k = 1, \dots, n\}$. An application of non-parametric technique on the data X results to the following:

$$\hat{\theta}_k = min\left\{\theta \,\middle|\, y_k \le \sum_{i=1}^{n} \gamma_i y_i \,\middle|\, \theta_{xk} \ge \sum_{i=1}^{n} \gamma_i x_i \,\middle|\, \sum_{i=1}^{n} \gamma_i = 1, \gamma_i \ge 0 \,\middle|\, \theta \ge 0 \,\middle|\, i = 1, \dots, n\right\} \quad (7)$$

To estimate the efficiency; $\hat{\theta}_k = min\{\theta \mid \theta_{x_k} \in \hat{X}(y_k)\}$ yields $\hat{X}\ and\ \partial\hat{X}(y)$. But the P in the DGP is unknown, hence bootstrap procedure generates $\hat{P}$ for the DGP as a true estimator of the unknown DGP via the data x. The efficiency estimates are from a new population; a product of new data set or pseudo data $X^* = \{x_i^* y_i^* \mid i = 1, \dots, n\}$. The bias component can be derived from the bootstrap procedure as follows: $BIAS(\hat{\theta}_k) = E(\hat{\theta}_k) - \theta$. Thus, the bootstrap bias for the original estimator $\hat{\theta}_k$ is:

$$BIAS_B(\hat{\theta}_k) = B^{-1}\left(\sum_{b=1}^{B} \hat{\theta}_{k,b}^*\right) - \hat{\theta}_k \quad (8)$$

The study used the Hall percentile interval based on differences as propose by Simar and Wilson (1998) for generating the confidence interval for the bias-corrected efficiency. If $\left(\hat{\theta}^{*}(x,y)-\theta(x,y)\right)$ has a known distribution, then it is possible to obtain a_α, b_α such that:

$$P_r\left(-b_\alpha \le \hat{\theta}_k(x_0,y_0)-\theta(x_0,y_0)\le -a_\alpha\right)=1-\alpha \quad (9)$$

But a_α and b_α are unknown, hence $\{\hat{\theta}^{*}_{k,b}\ b=1,\dots,B\}$ are used to predict them $\hat{a}_\alpha$ and $\hat{b}_\alpha$ as below:

$$P_r\left(-\hat{b}_\alpha \le \hat{\theta}^{*}_{k,b}(x_0,y_0)\le -\hat{a}_\alpha \mid \hat{P}(X_n)\right)=1-\alpha \quad (10)$$

To predict $\hat{a}_\alpha$ and $\hat{b}_\alpha$ requires sorting values as $\hat{\theta}^{*}_{k,b}(x_0,y_0)-\hat{\theta}_k(x_0,y_0), b=1,\dots,B$ in ascending order of magnitude and eliminate $[(\alpha/2)*100]^{\%}$ of rows at both upper and lower limits. Then, $-\hat{b}_\alpha$ and $-\hat{a}_\alpha$ are set at the extreme points of the array with $\hat{a}_\alpha \le \hat{b}_\alpha$. Thus, the $1-\alpha$ percent confidence interval becomes:

$$\hat{\theta}_k=(x_0,y_0)+\hat{a}_\alpha \le \theta(x_0,y_0)\le \hat{\theta}_k(x_0,y_0)+\hat{b}_\alpha \quad (11)$$

This procedure is repeated many times (n times) to obtain n confidence interval for a specified firm.

Determinants of Technical Efficiency in Broiler Production

A tobit regression for farm/farmer specific attributes was modeled as independent variables and the bias-corrected technical efficiency scores as dependent variables to determine factors influencing technical efficiency in broiler production. The equation is presented as follows:

$$TE_{bias-corrected}=\Psi_0+\Psi_1Z_1+\Psi_2Z_2+\Psi_3Z_3+\Psi_4Z_4+\Psi_5Z_5+\Psi_6Z_6+\Psi_7Z_7+\varepsilon_i \quad (12)$$

Where, $Z_1,\dots,Z_7$ represents system of broiler production, farmers' age, farmers' education, their business status, land status, and number of broiler farms owned by farmers. The symbol Ψ_0 denotes intercept and $\Psi_1,\dots,\Psi_7$ represents the coefficients of the independent variables $Z_1,\dots,Z_7$, respectively.

RESULTS AND DISCUSSION

Table 2 shows the result of the DEA estimator under input orientation for Variable Returns to Scale (VRS). The VRS model predicts the East/Central and the Southern as the most efficient and least efficient regions with 90.24 and 83.99%, respectively, as mean Technical Efficiency (TE). In other words, and on average, an inefficiency of 9.76 and 16.01% still exist in the East/Central and Southern regions, respectively. This means that increase in broiler production or decrease in its cost of production is still feasible. Heidari *et al.* (2011) estimated 91.89% as mean *TE* in Iran's broiler production; slightly higher than the estimate in this study.

However, Mahjoor (2013) predicted 87% as mean *TE* for broiler production in Fars Province of Iran; a score higher than the least efficient region and slightly lower than the most efficient regions in our study. In terms of fully efficient broiler farms, the majority (56.76, 41.18 and 35.67%) obtained 100% efficiency in the East/Central, Northern and Southern regions, respectively. Technical efficiency estimation based on CRS and NIRTS assumptions reveals almost similar TE scores both in magnitude and distribution.

The scale efficiency index shows that only 32.43, 22.55 and 13.38% of the farms are scale efficient in the East/Central, Northern and Southern regions, respectively. This means their combination of inputs and outputs are efficient under both CRS and VRS models. In terms of returns to scale, the majority (83.78, 97.06 and 97.45%) of the broiler farmers produce at increasing returns to scale. In those farms, increase in scale of production is advocated in order to attract higher marginal returns and, subsequently, lower marginal costs. About 16.22, 2.94 and

Table 2. Technical efficiency in broiler production based on DEA assumption for *VRS, CRS, NIRTS, SE* and Returns to scale.

	TE under *VRS* (PTE) Assumption			*TE* under *CRS* (OTE) Assumption			*TE* under *NIRTS* Assumption			Scale Efficiency			Returns to scale		
	NP	SP	E/CP	NP	SP	E/CP	NP	SP	E/CP	NP	SP	E/CP	NP	SP	E/CP
1st Quadrant (0.0000-0.2500)	00 (0.00)	00 (0.00)	00 (0.00)	02 (1.96)	05 (3.18)	00 (0.00)	02 (1.96)	05 (3.18)	00 (0.00)	01 (0.98)	02 (1.27)	00 (0.00)	00 (0.00)	00 (0.00)	00 (0.00)
2nd Quadrant (0.2501-0.5000)	07 (6.86)	04 (2.55)	00 (0.00)	24 (23.53)	35 (22.29)	05 (13.51)	24 (23.53)	35 (22.29)	05 (13.51)	08 (7.84)	20 (12.74)	02 (5.41)	00 (0.00)	00 (0.00)	00 (0.00)
3rd Quadrant (0.5001-0.7500)	21 (20.59)	43 (27.39)	06 (16.22)	35 (34.31)	56 (35.67)	10 (27.03)	35 (34.31)	56 (35.67)	09 (24.32)	30 (29.41)	31 (19.75)	07 (18.92)	00 (0.00)	00 (0.00)	00 (0.00)
4th Quadrant (0.7501-0.9999)	32 (31.37)	54 (34.39)	10 (27.03)	18 (17.65)	40 (25.48)	10 (27.03)	17 (16.67)	40 (25.48)	10 (27.03)	40 (39.22)	83 (52.87)	16 (43.24)	3 (2.94) **DRS**	04 (2.55) **DRS**	06 (16.22) **DRS**
Fully Efficient (Exactly 1.0000)	42 (41.18)	56 (35.67)	21 (56.76)	23 (22.55)	21 (13.38)	12 (32.43)	24 (23.53)	21 (13.38)	13 (35.14)	23 (22.55)	21 (13.38)	12 (32.43)	99 (97.06) **IRS**	98 (97.45) **IRS**	31 (83.78) **IRS**
Total	102 (100)	157 (100)	37 (100)	102 (100)	157 (100)	37 (100)	102 (100)	157 (100)	37 (100)	102 (100)	157 (100)	37 (100)	102 (100)	157 (100)	37 (100)
Summary															
Min	0.3782	0.3314	0.5806	0.1629	0.1479	0.3263	0.1629	0.1479	0.3263	0.2496	0.1984	0.3910	0.8911	0.9255	0.9378
Max	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Mean	0.8569	0.8399	0.9024	0.6900	0.6617	0.7795	0.6911	0.6623	0.7825	0.7929	0.7869	0.8601	0.9986	0.9992	0.9965
SD	0.1724	0.1676	0.1365	0.2466	0.2307	0.2163	0.2469	0.2308	0.2174	0.1980	0.2132	0.1855	0.0111	0.0065	0.0112

Survey data (2013)

2.55% of the farms in the East/Central, Northern and Southern regions operate under decreasing returns to scale. Implying that their scale of operation is larger than their current resource endowment; leading to decrease in marginal returns and subsequent decrease in marginal costs. In those farms, rationality exists for reduction in scale of operation so that their marginal returns and marginal costs are equal. Figures 1, 2, and 3 show the plots of *DEA-VRS* efficiency scores of broiler production in the Northern, Southern, and East/Central zones, respectively.

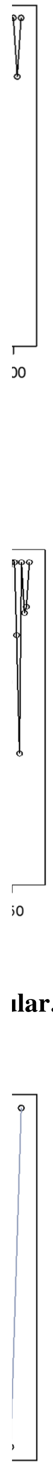
Table 3 presents four distinct but related *TE* estimates; the non-bias corrected *TE*, bias-corrected *TE*, its 95% confidence interval, and the component of bias in the broiler farming. It can be observed that the broiler farms produce at the same level of efficiency under both the non-bias corrected estimation using the conventional DEA model and the bias-corrected *TE* with DE-bootstrap model. Thus, the bias-corrected *TE* in the DEA-bootstrap method and the non-bias corrected *TE* estimates under the conventional DEA method are the same. This finding corroborates theoretical conception of the DEA that it only captures inefficiency, but it does not accommodate the exogenous factors inherent in production.

The bias-corrected *TE-VRS* estimates in the regions show, on average, broiler farms produce at 77, 76, and 82% in the Northern, Southern and East/Central regions, respectively. This indicates that the broiler farms in East/Central regions are most efficient, the Northern more efficient and the Southern the least efficient. Why is the East/Central region more technically efficient over others? Proliferations of feed mills and production of day old chicks abound more in the other regions than in the East/Central region. This situation put the East/Central region at a disadvantage owing to expensive feed cost and day old chicks. Being expensive in the region, the implication is that farmers in the East/Central are cautious of input utilization;

Table 3. Technical efficiency in broiler production based on bootstrap estimator for *VRS* assumption.

	Non-bias-corrected *TE*			Bias-corrected *TE*			Confidence interval for bias-corrected *TE* (Lower-upper Limit)			Bias component		
	N. P	S. P	E/C. P	N. P	S. P	E/C. P	N. P	S. P	E/C P	N. P	S. P	E/C P
1st Quadrant (0.0000-0.2500)	00 (0.00)	00 (0.00)	00 (0.00)	00 (0.00)	00 (0.00)	00 (0.00)	-	-	-	-	-	-
2nd Quadrant (0.2501-0.5000)	07 (6.86)	04 (2.55)	00 (0.00)	08 (7.84)	09 (5.73)	00 (0.00)	-	-	-	-	-	-
3rd Quadrant (0.5001-0.7500)	21 (20.59)	43 (27.39)	06 (16.22)	29 (28.43)	51 (32.48)	10 (27.03)	-	-	-	-	-	-
4th Quadrant (0.7501-0.9999)	32 (31.37)	54 (34.39)	10 (27.03)	65 (63.73)	97 (61.78)	27 (72.98)	-	-	-	-	-	-
Fully Efficient (Exactly 1.0000)	42 (41.18)	56 (35.67)	21 (56.76)	00 (0.00)	00 (0.00)	00 (0.00)	-	-	-	-	-	-
Total	102 (100)	157 (100)	37 (100)	102 (100)	157 (100)	37 (100)	102 (100)	157 (100)	37 (100)	102 (100)	157 (100)	37 (100)
Summary												
Min	0.3782	0.3314	0.5806	0.3506	0.2992	0.5358	0.3201-0.3763	0.2577-0.3288	0.4800-0.5778	0.0276	0.0322	0.0442
Max	1.0000	1.0000	1.0000	0.9217	0.9220	0.9418	0.8562-0.9954	0.8687-0.9948	0.8939-0.9962	0.1533	0.1600	0.1239
Mean	0.8569	0.8399	0.9024	0.7703	0.7554	0.8188	0.6761-0.8520	0.6752-0.8339	0.7204-0.8977	0.0866	0.0846	0.0836
SD	0.1724	0.1676	0.1365	0.1435	0.1399	0.1158	0.1207-0.1722	0.1215-0.1669	0.0988-0.1376	0.0388	0.0385	0.0306

Source: Survey data (2013)



ılar.

Figure 3. TE-VRS for East-central Peninsular.

intolerant to input waste. Farmers in other regions may not be too wary of the need for judicious input (feeds) utilization, more so, they float in near abundance of such inputs at cheaper rates. Figures 4, 5 and 6 show the plots of bootstrap (VRS) efficiency scores for broiler production in the Northern, Southern and East/Central zones, respectively. The study also finds the bias-corrected *TE* estimates to fit in to its 95% confidence interval; an indication that the estimates are indeed plausible.

In terms of bias estimate, farms in the Northern Peninsular seem to harbor the highest mean bias of 8.66% relative to 8.46 and 8.36% for the Southern and East/Central peninsular, respectively. These infer that there are more exogenous causal factors of frontier deviation in Northern part relative to other regions of the Peninsular.

The exogenous factors in broiler production may emanate from disease and poor weather (temperature) often resulting in mortality. Although more of managerial flaw than natural, the rare case of overstocking the birds mostly in open-smallholder farms is also common. Bias estimate; a product of non-bias-corrected *TE* scores less its bias-corrected counterpart, is also presented in the table3. Figures 7, 8, and 9 present the plots of bias components (VRS) efficiency scores for broiler production in the regions. The table 3 also

shows the confidence interval for the bootstrap efficiency; interesting to note that all bootstrap efficiency consistently fits within its confidence interval. Figures 10, 11, and 12 also present the plots of DEA-bootstrap (VRS) confidence interval for broiler production in the Northern, Southern, and East/Central zones, respectively.

Table 4 presents the t-test results showing significant difference in efficiency between the 2 estimators across the 3 regions. The result indicates that the efficiency scores from the conventional DEA and the bootstrap models are statistically significant at 1% level across the three regions.

In comparison, farms in the East/Central region produce with higher efficiency than

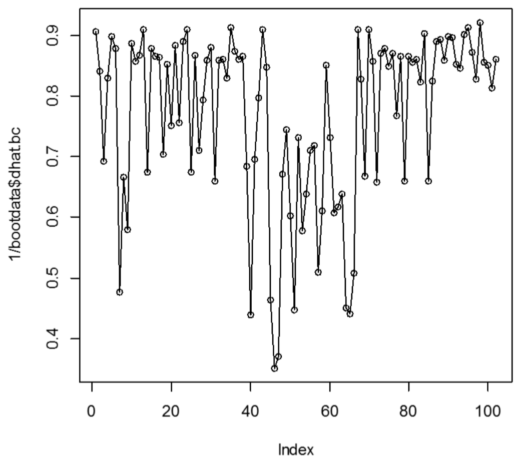


Figure 4. TE-BOOT for Northern Peninsular.

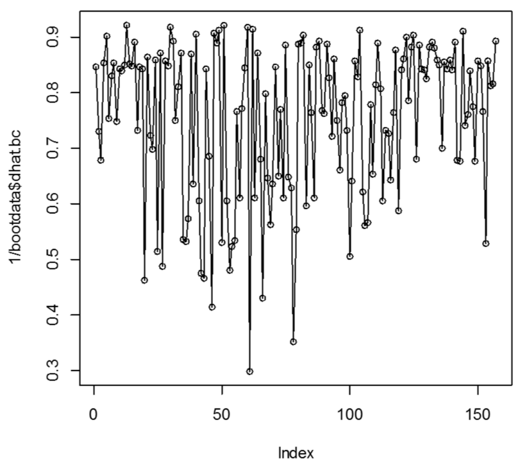


Figure 5. TE-BOOT for Southern Peninsular.

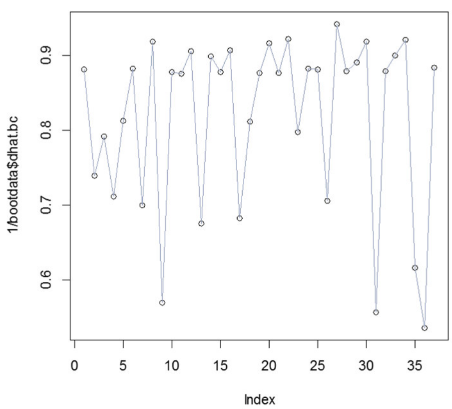


Figure 6. TE-BOOT for East-Central Peninsular.

those in the Northern and Southern Peninsular. It is evident that cost of day old chicks and feeds are more expensive in the East and Central Peninsular relative to the Southern and Northern Peninsular. These financial predicaments of broiler farmers in the East/Central orient them to manage well their farm inputs, thus, a good justification for their higher efficiency. The availability of feed mills in the Southern and Northern Peninsular tempt farmers to build a care-less attitude in managing their feed resource.

The determinants of efficiency model or farm specific factors influencing technical efficiency of broiler farming in the 3 regions (Northern, Southern and East/Central) are presented in Table 5. On average the study found all variables included in the model as statistically significant and with the appropriate signs. The determinants of technical efficiency show that system of production is consistently (-) and significant with (P< *0.01*) in southern and (P< *0.05*) in both East-central and Northern peninsular. The negative sign indicates that farmers who operate closed system are more efficient than those under open system. This finding is not unusual and is, indeed, rational as the closed systems of broiler production deploy more technology and management relative to the open systems. While farmers under the open system produced at 74% mean *TE*, those under the closed system produced at a higher mean *TE* of 79%. The coefficient of experience consistently shows significant (+) with (P< 0.01) in both Southern and Northern peninsular. This also means that more experienced farmers are more technically efficient than farmers with less production experience.

In terms of age of farmers, the study revealed (+) coefficient and significant with (P< 0.01) in both East-central and Northern regions. This means that technical efficiency increases with age and suggest that older farmers are more efficient than younger ones. The fact that older farmers garner more production experience and skills than younger farmers and its reflection on efficiency makes this finding accommodating. Several studies such as Akhter and Rashid (2008), Alrwis and Francis (2013) and Ali *et al.* (2014) concur with the present finding on positive significant relationship between age and technical efficiency in broiler production. Educationally, positive (+) and significant (P< *0.1*) and (P< *0.01*) were observed in East-central and Northern peninsular, respectively. This implies that education influences technical efficiency. Better educated farmers tend to produce at higher *TE* than less educated farmers.

This finding also corroborates many efficiency studies on broiler across the globe, such as Todsadee *et al.* (2012), Akhter and Rashid (2008), Yusef and Malomo (2007), Begum *et al.* (2010) and Alabi and Aruna (2005).The study also found a positive (+) and highly significant relationship (P< *0.01*) between business status and technical efficiency; an indication that contract farmers are more efficient than non-contract farmers.

Contract farmers have some contractual agreements to fulfill; as a result, they are more dedicated to achieving their contractual agreement. Relative to non-contract farmers, contract farmers are more efficient, with less risk, and obtain higher returns (Nguyen *et al..,* 2011). Chang (2007) also stated that contract farming and vertical integration is globally viewed as the most efficient broiler farms leading to enhanced production, market efficiency and value added potentials at lower costs. The coefficient of number of farms owned was consistently positive (+) with (P< *0.01*) in the entire peninsular. The negative sign and significance of number of farms owned means that farmers who own one or few broiler farms are more technically efficient than those with multiple farms. This is also rational; the more farms a farmer has, the more input (capital, land, labor, management and time) he will deploy and management becomes cumbersome leading to inefficiency. But, farmers with one or few farms do not suffer the hassle of sourcing extra resource and their management is less cumbersome leading to higher efficiency. The coefficient of farm land status consistently shows positive (+) and significant ($P< 0.01$) relationship with technical efficiency. This implies that farmers with rented land status are more efficient than those with private land status.

CONCLUSIONS

In conclusion, this study contributes to the literature on efficiency of broiler production by investigating it using two distinct methods for comparison. The study revealed that both inefficiency and noise exist in broiler production in Peninsular Malaysia. The two estimators: DEA and DEA-Bootstrap for estimating efficiency were found to be significantly different from zero across the regions. The study also established a positive relationship between technical efficiency and age, education and production system and negative association with number of poultry farms owned. The noise components of the frontier deviation compose of unfavorable weather and diseases. Overstocking in some open-smallholder farms is a major management flaw in the broiler production. The noise and the overstocking are the major cause of broiler mortality in the Peninsular. Enhancing efficiency via cost reduction or/and increased production is feasible in broiler production, particularly by stocking more day old chicks in most farms to tap the benefit of economy of scale as most farmers produce at increasing returns to scale. Manipulating these efficiency indicators will place the contribution of the broiler industry to the Malaysian economy in yet a vital position.

ACKNOWLEDGEMENTS

Research grant (No: 5526015) from Ministry of Education (MOE), Malaysia approved for this study is highly appreciated.

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شبیه سازی منطقه ای کارآیی بوت استرپ تولید جوجه های کبابی در بخش شبه جزیره ای مالزی

ب. ه. گبدو، م. ی. منصور، ه. ا. و. کمال، و ا. م. ایلماس

چکیده

بوت استرپینگ تحلیل پوششی داده ها(DEA) یکی از روش های جاری اندازه گیری کارآیی مقاوم به وسیله ایجاد فاصله اطمینان و سنجش اختلال (اریب بودنbias) در تولید است. در این پژوهش، دو برآوردکننده شامل روش مرسوم تحلیل پوششی داده ها و دیگری شبیه سازی بوت استرپ با ۲۰۰۰ تکراربوت استرپ روی داده های مقطعی ۲۹۶ مزرعه مرغداری در بخش شبه جزیره ای مالزی به کار گرفته شد. هدف پژوهش اندازه گیری کارآیی فنی و مقاوم ، اریبی تولید، و عوامل موثر در کارآیی فنی در مناطق شمالی، جنوبی، و بخش شرقی-مرکزی بخش شبه جزیره ای مالزی بود. در این روش

منطقه ای، نتایج حاکی از وجود ناکارآمدی و اختلال(noise) در مزارع مرغداری در سراسر مناطق بخش شبه جزیره ای مالزی بود. یافته ها نشان میدهد که آلودگی به امراض و درجه حرارت های نامناسب اجزای پدیده اختلال یا عوامل برونی خارج از کنترل مرغداران در تولید جوجه های کبابی هستند. در این پژوهش، عواملی مانند سن (+)، آموزش(+)، تجربه(+) سیستم یا سامانه تولید(–) ، تعداد مزارع مرغداری تحت مالکیت یک فرد(–)، موقعیت شغلی(+) و وضعیت مالکیت زمین (–) از نظر آماری تاثیر معنی دار در بهبود کارآیی در تولید جوجه های کبابی داشتند.همچنین، نتایج نشان دهنده اختلافات قوی معنا داری بین دو برآوردکننده مزبور در سراسر مناطق بود. توصیه این پژوهش افزایش مقیاس تولید است چرا که بازده تولید اکثر مرغداران متناسب با مقیاس فزونی می‌گیرد.